Evaluation of Advance Warning Signal Installation
Phase I Summary Presentation

Grant G. Schultz, Ph.D., P.E., PTOE
Assistant Professor, Brigham Young University

Ryan Peterson, EIT
Graduate Research Assistant, Brigham Young University

Bradley C. Giles
Systems Engineer, Wavetronix LLC

Dennis L. Eggett, Ph.D.
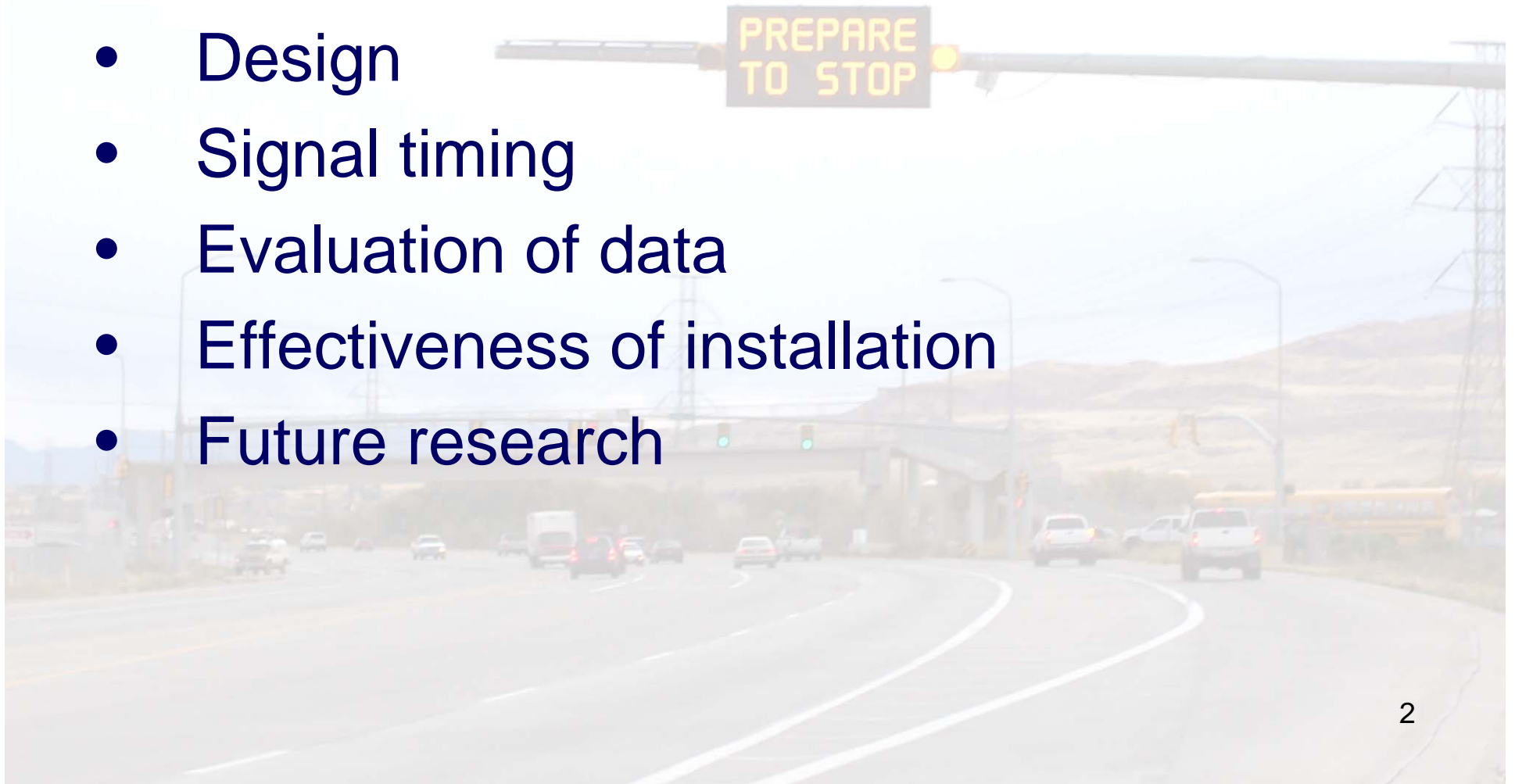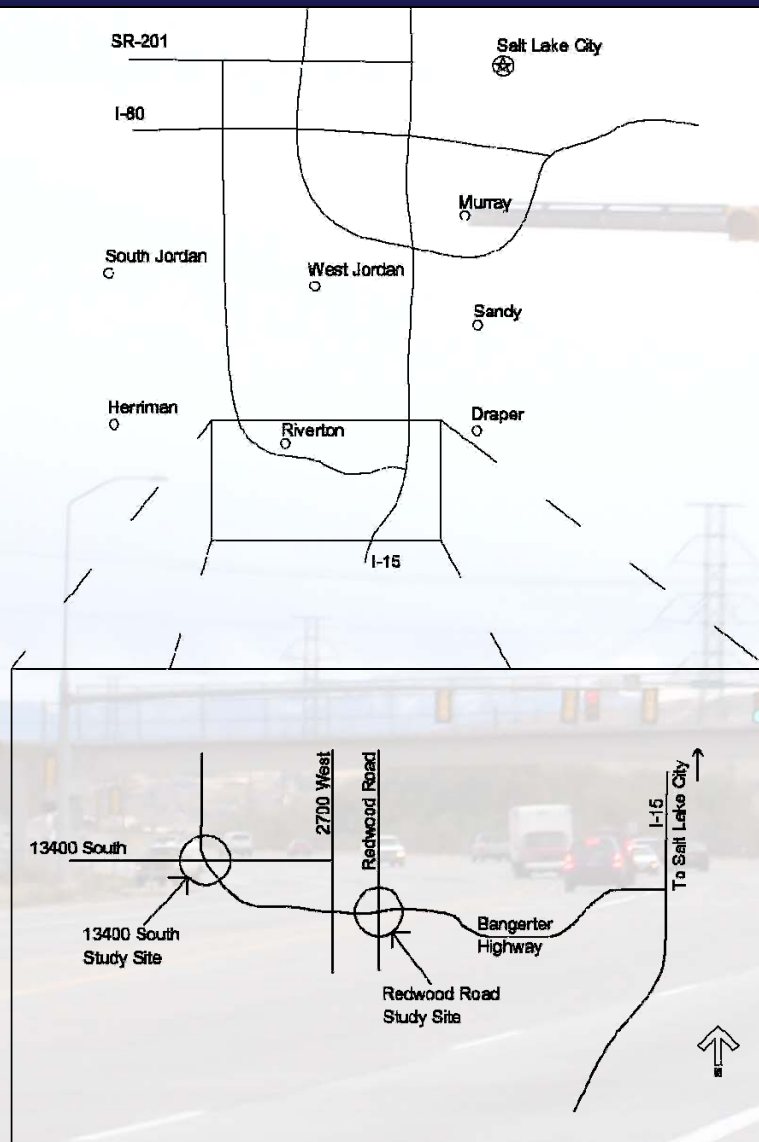**Associate Professor, Brigham Young University**

June 2006

OVERVIEW

- Background
- Design
- Signal timing
- Evaluation of data
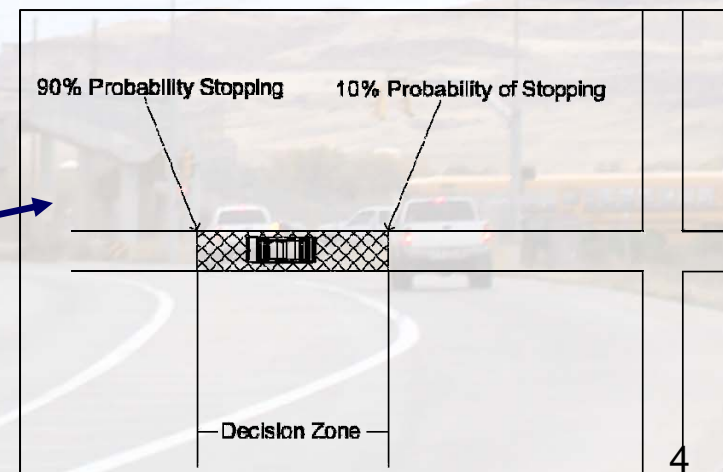- Effectiveness of installation
- Future research

BACKGROUND
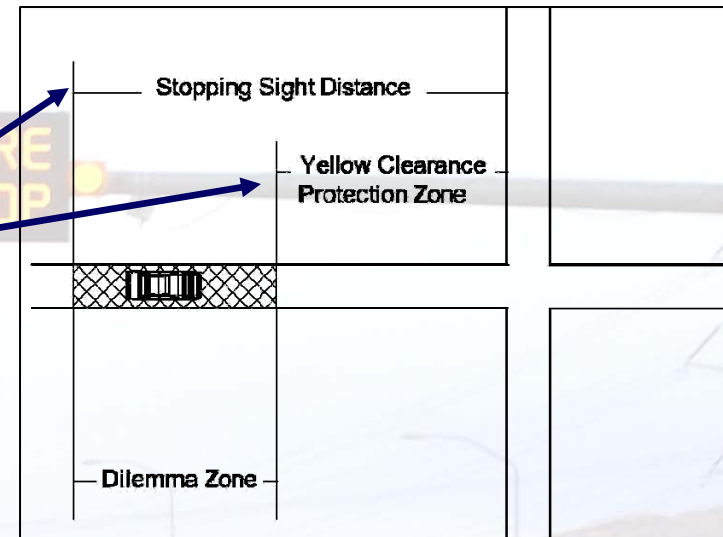*Site Location*

13400 South

Redwood Road

3

- ## Dilemma zone (DMZ):
  - Not enough distance to stop
  - Not enough time to proceed
  - Improper signal timing

- ## Decision zone (DCZ):
  - Variation in driver behavior
  - Design assumptions not met
  - Motorists caught unaware
  - 90% - 10% probability stopping distances

Stopping Sight Distance

Yellow Clearance Protection Zone

Dilemma Zone

90% Probability Stopping   10% Probability of Stopping

Decision Zone

4

BACKGROUND

- **Advanced detection:**
  - Reduce the number of vehicles caught in the DMZ at the onset of yellow

- **Advance warning signals:**
  - Warn motorists of impending signal changes in an effort to reduce the variation in motorist behavior

DESIGN

- Design of the project was completed by Project Engineering Consultants, Ltd.

- Three locations on Bangerter Highway:
  – Redwood Road
  – 2700 West
  – **13400 South**

- One location on SR-201

- All intersections have posted speeds of 60 mph

- 85th percentile speeds were 63-64 mph

6

DESIGN
Study Location

Bangerter Highway and 13400 South

USGS

DESIGN
The Signs

- "Blank-Out" LED with side-mounted flashers

- Two rows of 14" letters

- 48" x 96" x 12" 300 lbs

- State-Furnished Item

DESIGN
The Installation

- Standard 75' mast arm and signal pole with mast arm cut to 55' length

- Horizontal damping "wing" at end of arm (2' x 8' panel)

- 65 mph design speed

- AWS placed 445' from stop bar; luminaire and video camera at 705'; detection zone at 755':

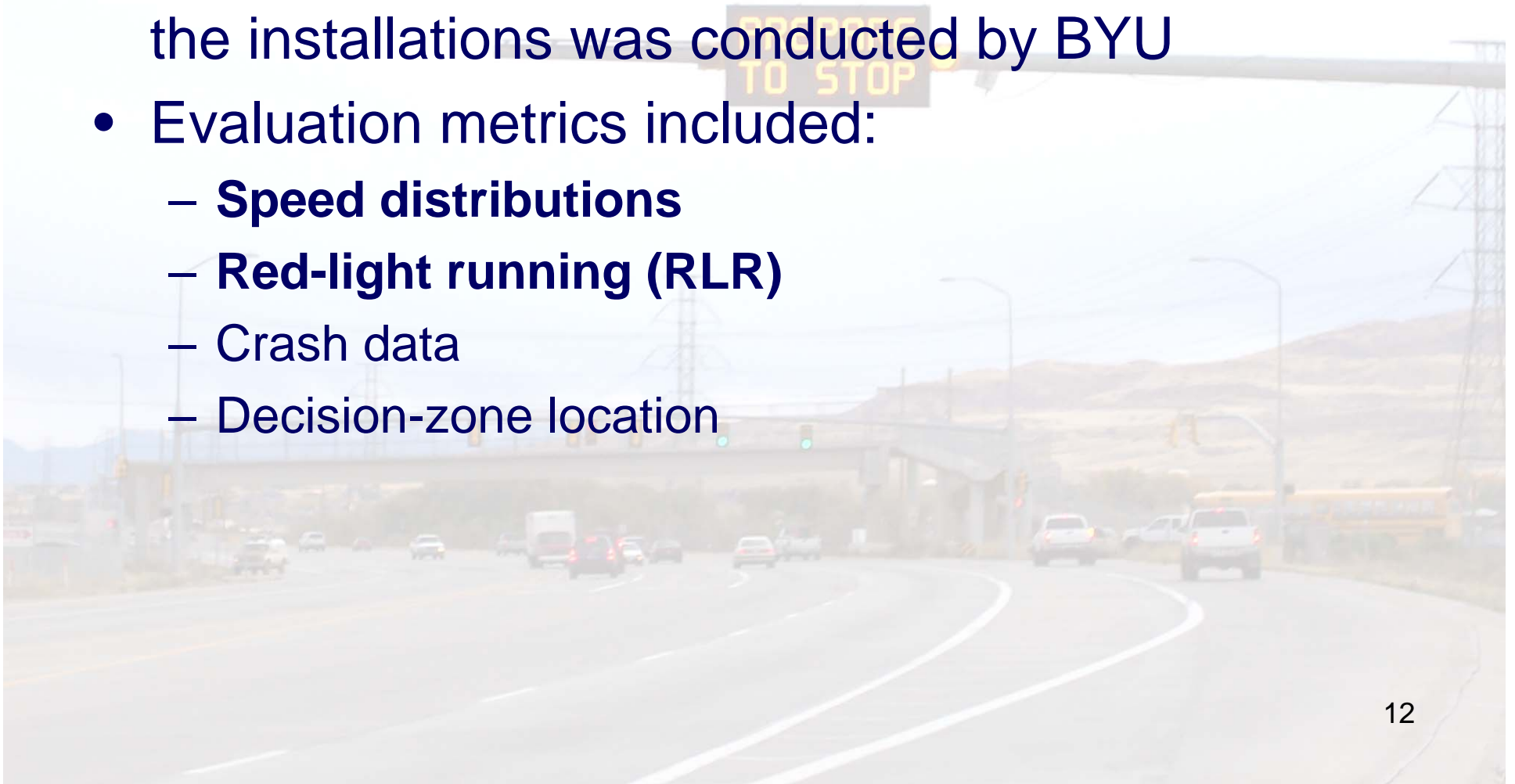 - Based on a 2002 Nebraska Department of Roads study

9

SIGNAL TIMING

- AWS comes on 6 seconds before end of green (lead-flash time)
- AWS remains on during the red
- AWS turns off once arterial turns green

EVALUATION

- Evaluation of the data and the effectiveness of the installations was conducted by BYU

- Evaluation metrics included:
  - **Speed distributions**
  - **Red-light running (RLR)**
  - Crash data
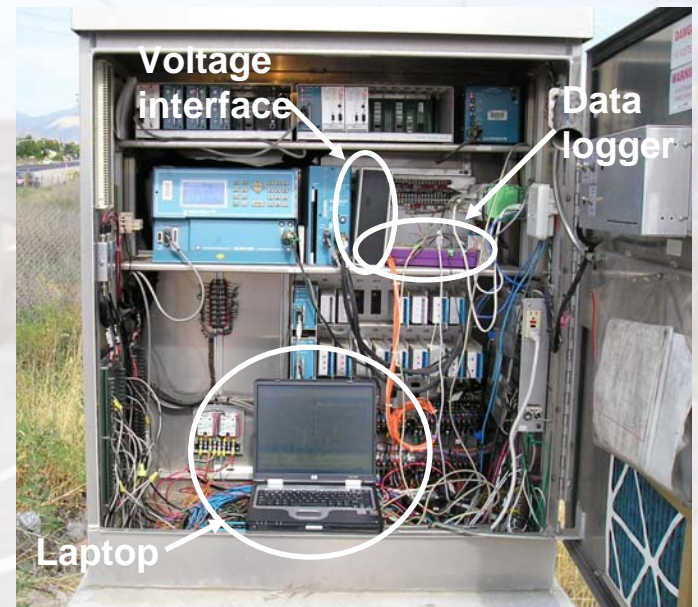 - Decision-zone location

12

EVALUATION

- BYU partnered with Wavetronix LLC to collect data using:
  - SmartSensor Advance™ digital wave radar
  - Wireless communication devices
  - Contact closure devices
- In addition, UDOT provided the following equipment:
  - Voltage interface
  - Data logger
  - Laptop computer

Radar sensor

Voltage interface

Data logger

Laptop

Data Collection Equipment – 13400 South

AWS Data Collection System Diagram
Bangerter & 13400 South

14

EVALUATION

- Speeds are recorded for each vehicle in 8 zones
- Red signal phases are time stamped
- Signal data is logged in the datalogger
- Speed data is logged on the laptop computer
- Post processing of the signal data and speed data allows red-light runners to be identified

Sensor 445'

Zone 1 300'
Zone 2 250'
Zone 3 200'
Zone 4 150'
Zone 5 100'
Zone 6 50'
Zone 7 0'
Zone 8 -50'

EVALUATION
Data Collection

- Data was collected for several months prior to activation of the system

- System activation occurred in June 2005 with data collected continuously since activation

- Data analysis included:
  - Before activation
  - Immediately after activation
  - 8 months after activation
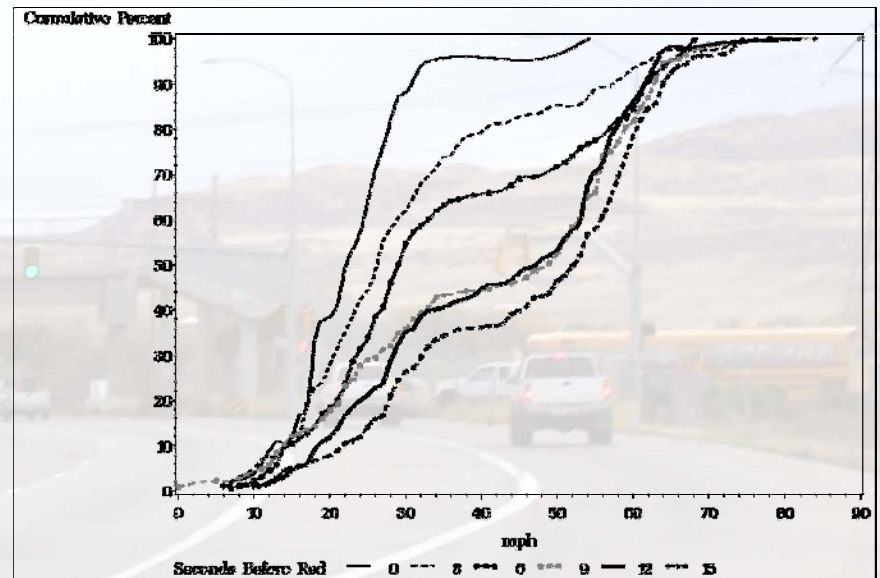
- Speed data cumulative distributions:
  – Organized by time of day, approach, sensor zone, and number of seconds before red
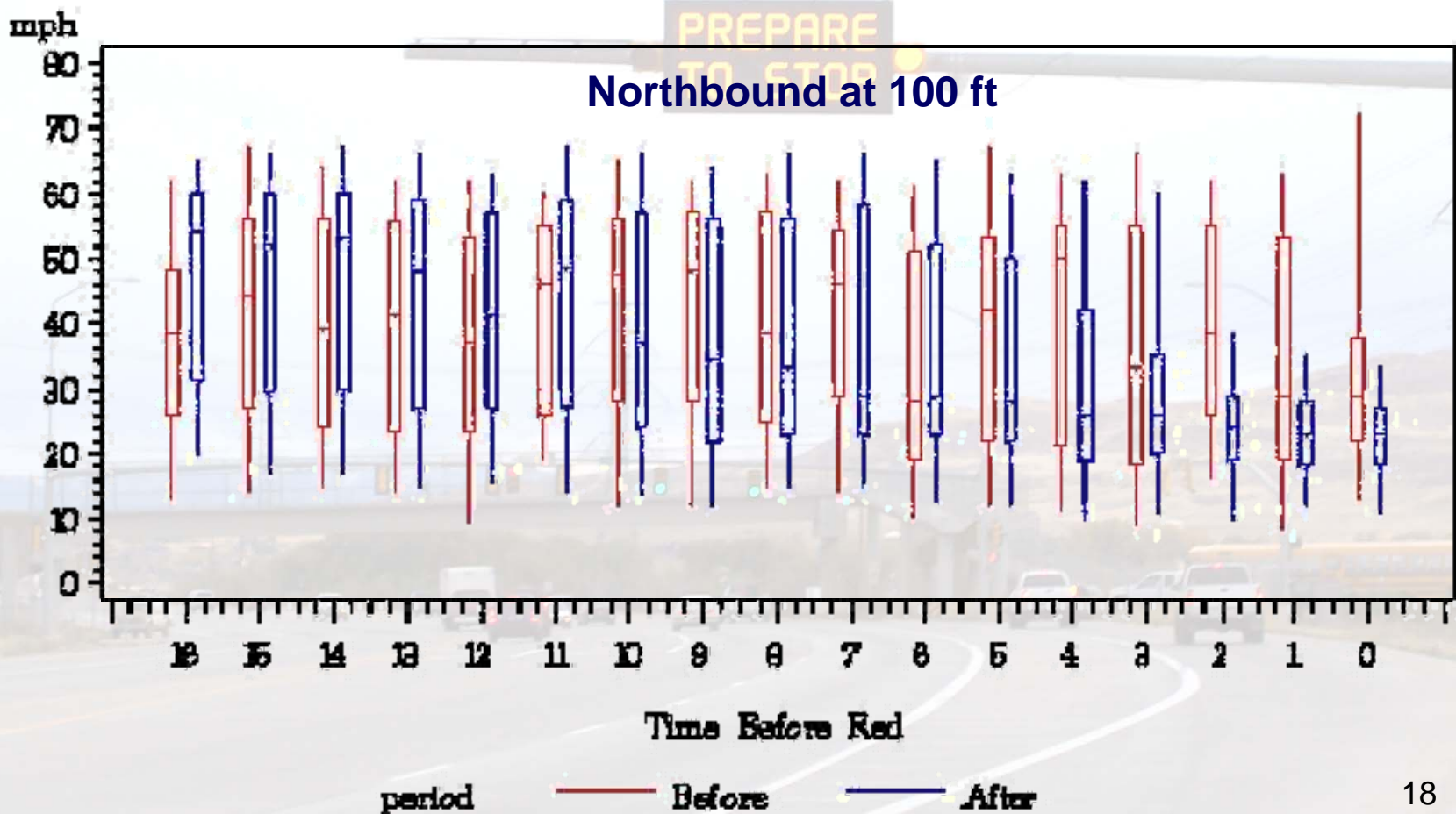
Before, Northbound, 100 ft   **Immediately After, Northbound, 100 ft**
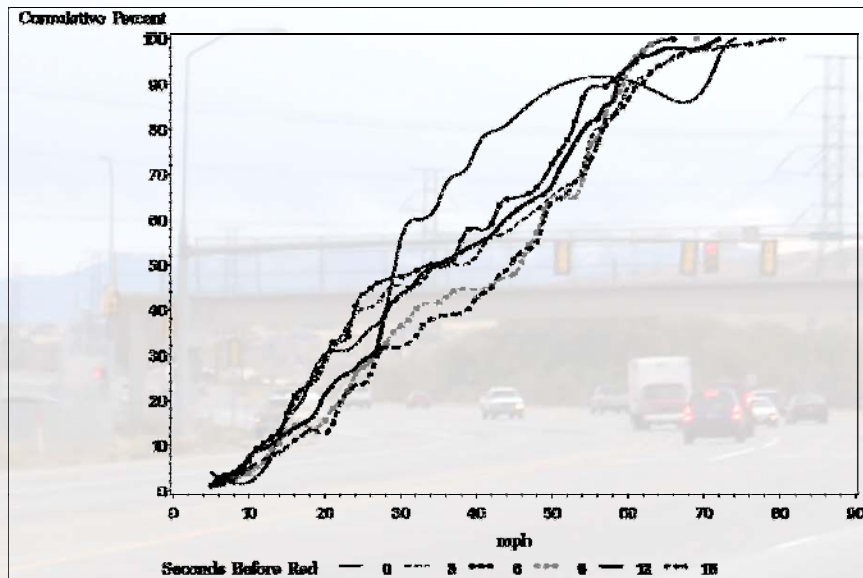
17

EFFECTIVENESS
Preliminary Results at 13400 South

- Speed data box plots:

Northbound at 100 ft

18

Preliminary Results at 13400 South

- Speed data statistical significance grids:

Evening — NB

	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
300		■	■	■	■	■	■	■	■								
200	■	■	■		■			■		■			■		■		
100	■	■	■	■	■					■			■				
50	■	■	■	■	■	■	■	■				■	■	■		■	

Afternoon — NB

	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
300	■				■							■	■	■	■		
200	■	■		■				■				■	■	■	■	■	■
100		■	■	■				■				■	■	■	■	■	■
50	■	■	■	■								■	■	■	■	■	■

Morning — NB

	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
300	■	■	■									■		■			
200	■	■	■	■								■	■	■	■		
100	■	■	■		■							■	■	■	■	■	
50	■	■	■		■								■	■	■	■	

19

- Red-light running data results:

	Before	% of Total	After	% of Total	% Change	Probability
NB	5.626	0.56	1.233	0.12	-78%	< .0001
SB	1.806	0.18	0.497	0.049	-72%	< .0001

*Red-light running events per 1,000 entering vehicles (single approach stop bar counts only)

- RLR data was filtered with 4-second after red and 20 mph speed thresholds
- UDOT manual counts used to verify sensor data

EFFECTIVENESS
Preliminary Conclusions

- AWS signs appear to affect driver behavior even when they are not flashing

- Motorists were traveling at higher and more constant speeds before the signs came on

- Motorists were slowing down and more motorists were stopping after the light turned yellow

- The total number of red-light runners at the intersections was reduced immediately after system activation
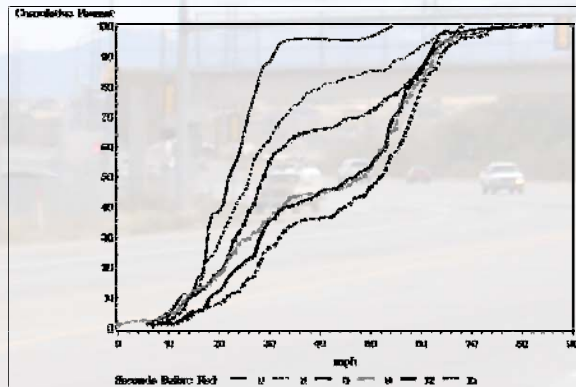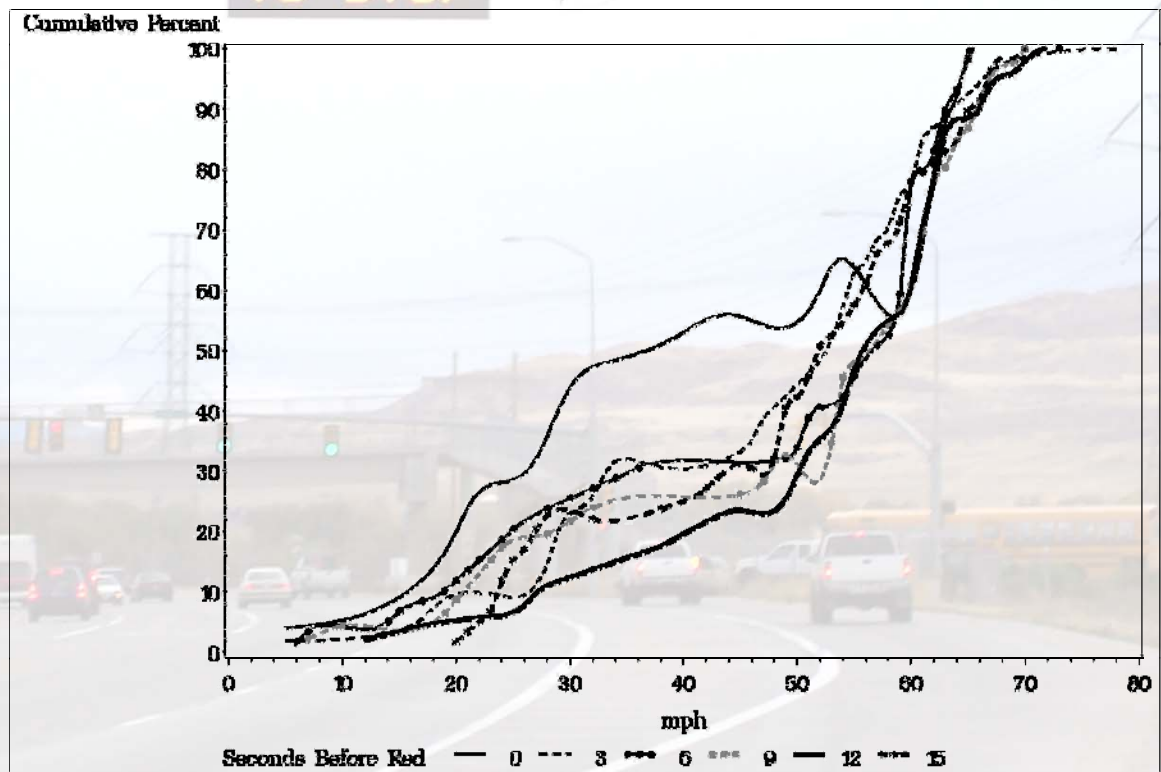
EFFECTIVENESS
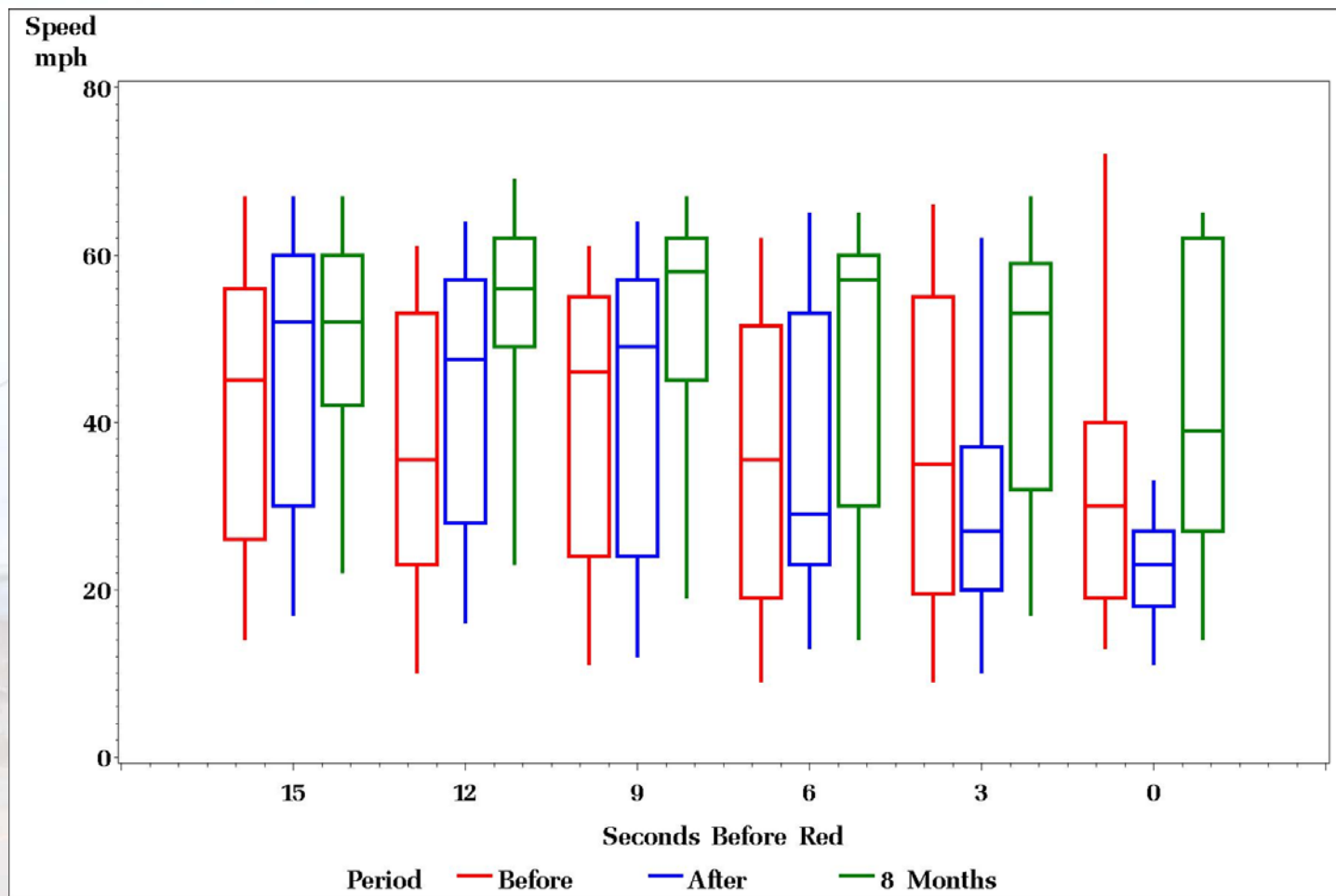*Eight-month After Results*

Before

8-Months After

Immediately After

22
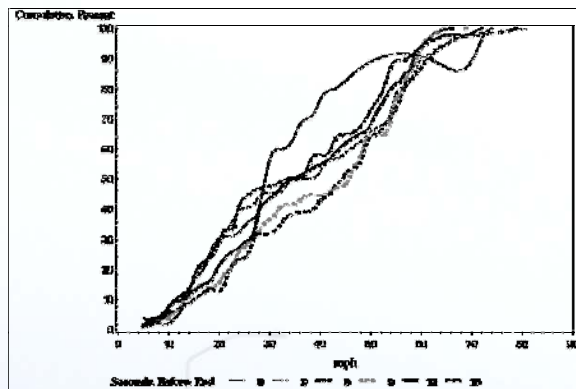
Eight-month After Results

EFFECTIVENESS

- Eight months after the system was installed:
  - Speed distributions returned to similar trends as before installation
  - Red light running increased to levels slightly higher than before installation in some instances
  - Crash rates decreased
  - Decision zone remained relatively constant
- Lead flash time theorized to be too conservative

FUTURE RESEARCH

- Modify lead-flash timing and evaluate effectiveness:

$$t_{F(DCZ)} = \frac{D_M + D_P}{v_0} - DCZ_n$$

  – Monthly evaluation

  – Monitor six to eight months after final changes made

- Follow-up research project:

  – Establish guidelines for future installations

  – Identify locations that fall within guidelines

  – Prioritize locations for future installations

QUESTIONS?

- For more information, contact:

  Grant G. Schultz, Ph.D., P.E., PTOE

  Department of Civil & Environmental Engineering

  Brigham Young University

  gschultz@byu.edu

  (801) 422-6332